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If You Build It, They Will Come: Ranching, Riparian Revegetation, and Beaver Colonization in Elko County, Nevada

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Cover photo: Scott River, California. Photo by Susan Charnley.

Abstract

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In Elko County, Nevada, grazing practices on federal and private lands began to change in the early 1990s to restore proper functioning condition to degraded riparian areas that provide habitat for Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*), which is listed as threatened under the Endangered Species Act. Changes in grazing management focused on changing the frequency and duration of hot-season grazing in riparian areas. These changes led to the recovery of riparian vegetation accompanied by the natural colonization of streams by beavers. Beavers and their dams, in turn, have enhanced the restoration process. People interviewed for this study observed more water in streams, and water available later into the dry season and during drought years, as one consequence of beaver colonization. They also observed the expansion of green zones in riparian corridors, including more wet meadows and riparian vegetation. Ranchers interviewed identified many benefits of beavers for their ranching operations, especially increased water availability and forage production for livestock. These changes improve livestock health and weight gains, which may translate into financial gains. Ranchers also described drawbacks of beavers, most notably their tendency to dam up irrigation canals that run through hay fields, impeding the flow of water. However, most ranchers believed the benefits of beavers outweigh the drawbacks. Variables that have contributed to successful riparian revegetation as an approach to beaver-related restoration in Elko County include low harvest pressure on beavers, large ranch size, compatible grazing practices, agency and permittee flexibility to try new approaches, strong collaborative relations among agency staff and permittees fostered through long-term relationship building, peer learning through site visits to ranches that demonstrate the benefits of changing grazing management, and research and monitoring to document project outcomes.

Keywords: Beavers, ranchers, grazing, range management, watershed restoration, Bureau of Land Management, U.S. Forest Service.

Contents

Introduction

> It started out as a grazing story, then a beaver story. Now, it's a water story, but it's really, probably, a soil story because what [beavers are] doing is creating these floodplains with this rich, organic soil with a lot of carbon, which really holds water (interview 4).

Although rare in Nevada, the most common approaches to beaver-related watershed restoration are beaver translocation or construction of artificial structures that mimic the effects of beaver dams (Pilliod et al. 2018). Another often unreported strategy entails riparian revegetation by excluding grazers or browsers (domestic or wild), or changing grazing management, to encourage the establishment of riparian shrubs and trees that are used by beavers for food and dam building. A related technique is to actively plant vegetation to promote stream restoration and create beaver habitat. Once beaver habitat is created, beaver colonization and dam building may follow (fig. 1). These projects are often unreported as beaver-related restoration because they may not start out as such. Instead, riparian restoration for other purposes (such as fish recovery) may unexpectedly result in the co-benefit of beaver moving into the area and building dams once revegetation takes place, further contributing to restoration. Such is the case in Elko County, Nevada.

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Figure 1—Beaver dam in the Thousand Springs basin built by beaver that colonized after changes in grazing management led to riparian revegetation.

Project Facts

Goal

- Restore aquatic and riparian habitat for Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) by changing grazing management.

Type

Riparian revegetation along streams with natural beaver colonization.

Land Ownership

Private and federal lands.

Initiation Date

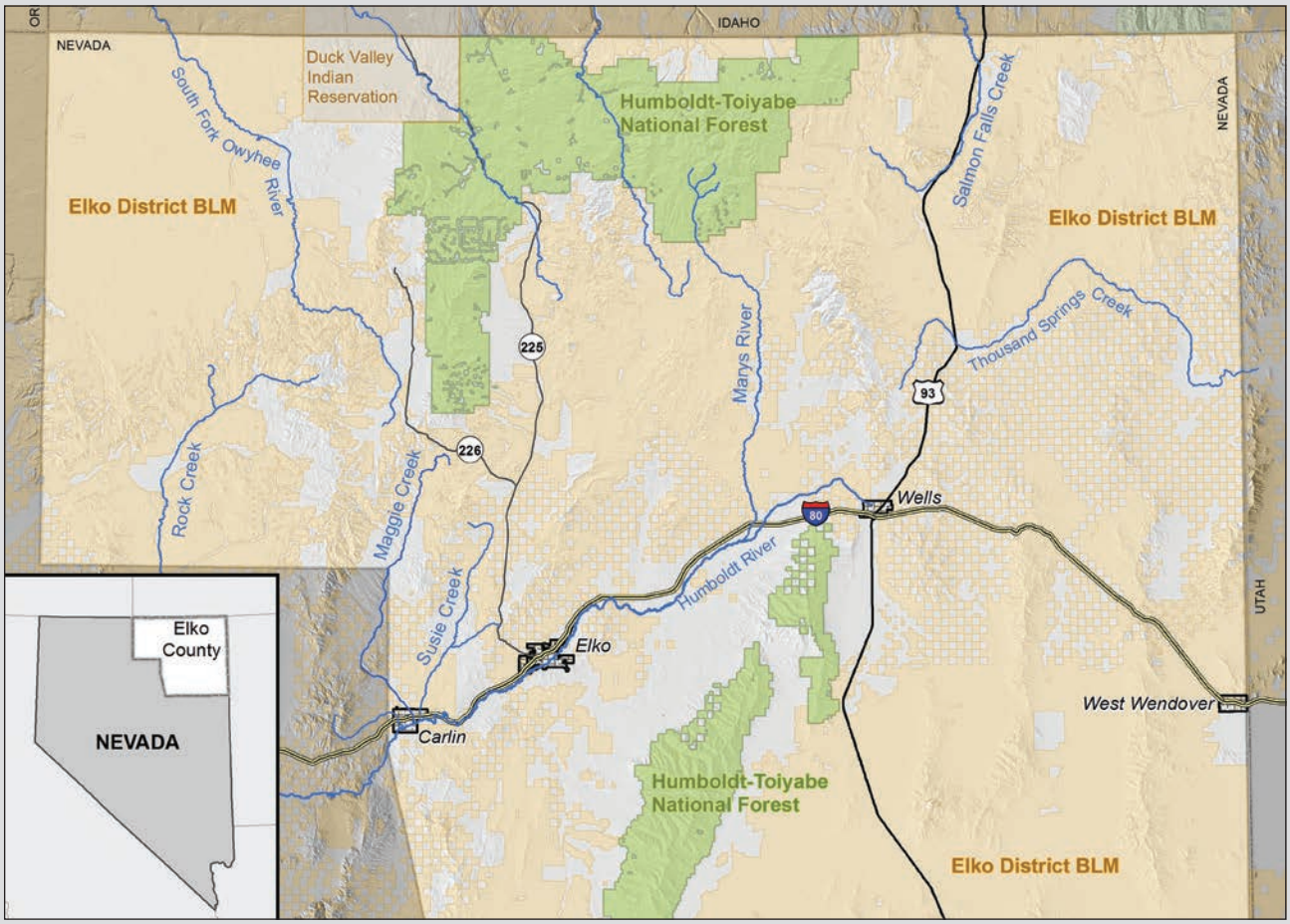
Early 1990s.

Implementing Partners

- Bureau of Land Management
- U.S. Forest Service
- Local ranchers
- Newmont Mining Corporation
- Barrick Goldstrike Mines
- Trout Unlimited
- University of Nevada Cooperative Extension

Location

Elko County, Nevada, including the Rock Creek, Maggie Creek, Susie Creek, Mary's River, Salmon Falls Creek, and Thousand Springs drainages.



Mark D Adams

This is one of five case studies conducted to investigate the social context of beaver-related restoration in western rangelands with a focus on ranchers' perspectives. This study describes how changes in grazing management led to beaver colonization in Elko County, factors that made changes in grazing management successful, how beaver colonization has affected ranching in the region, ranchers' perspectives on beavers, and lessons learned for promoting beaver-related watershed restoration through riparian revegetation in western rangelands.

Methods

I used two main methods to develop this case study: interviews with ranchers and federal and state agency staff involved in beaver and livestock management, and a review of relevant literature, databases, and websites. I conducted 21 semi-structured interviews between June and August 2016 during two week-long field trips. Of these, 20 were in-person interviews and one was a telephone interview. Twenty-seven people were interviewed: 21 ranchers who either owned or managed a ranch in Elko County north of Interstate Highway 80 (representing 14 ranches), and 6 state and federal agency employees who have been involved with the project or have related expertise (affiliated with the Nevada Department of Wildlife [NDOW], Nevada Division of Water Resources, U.S. Forest Service, or Bureau of Land Management [BLM]).

Ranchers were purposefully selected based on the location of their ranches and involvement in the project. The project was concentrated in several hydrographic areas that drain to the Humboldt River Basin in Elko County, including Rock Creek, Maggie Creek, Susie Creek, and Mary's River; the Thousand Springs basin (with interior drainage); and the Salmon Falls Creek drainage, which flows to the Snake River in Idaho (see "Project Facts" on page 2). Most ranchers interviewed resided in these watersheds, though I also interviewed ranchers in Independence Valley, where the south fork of the Owyhee River flows toward the Snake River. Thirteen ranchers were directly involved as project participants, and eight were not (representing five ranches). I interviewed nonparticipants to learn how they may have been affected by the project, and their views on beavers.

I recorded, transcribed, and coded the interviews using ATLAS.ti® software.[1] Interview codes were analyzed and the information synthesized by topic area covered in this case study (see Miles and Huberman 1994). I also reviewed relevant published and gray literature from the study area and obtained data from agency files and publicly accessible websites. I circulated a draft of the case study among key project participants for review and comment, and obtained project updates, in October and November 2018, then revised it. All of the information contained in this case study comes from interviews unless otherwise referenced.

[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Ranching Context

Encompassing 17,157 mi^2 (44 436 km^2), Elko County is the fourth-largest county in the lower 48 United States. Of this, 73 percent is federally owned, 25 percent is private, and 1.5 percent is tribally owned (including the Shoshone-Paiute Tribes of the Duck Valley Indian Reservation ownership); the remaining 0.5 percent is other public land (Elko County Assessor's Office 2016). Most of the federal land in the county (86 percent) is managed by the BLM (Headwaters Economics 2018a) and forms part of its Elko District. The remaining 14 percent is managed by the U.S. Forest Service (Headwaters Economics 2018a) and lies within the Humboldt-Toiyabe National Forest.

The county is dominated by the basin and range topography that is characteristic of the Great Basin. Elko County has 14 major valleys with elevations of 4,000 to 6,000 ft (1219 and 1829 m) where private ranches are located (Starrs 1998). Watercourses running through these valleys provide water for livestock and irrigated hay production, and the mountains rising several thousand feet above them offer summer forage (Starrs 1998). Land cover in the county is 95 percent grassland and shrubland (Headwaters Economics 2018a), with sagebrush (*Artemisia* spp.) predominant in the basins, and riparian areas containing willows (*Salix* spp.) and other woody and herbaceous plants (Horton 2000, Neville et al. 2016). Rainfall is low, averaging 10 inches (24.5 cm) annually (U.S. Climate Data 2018), although there is a high degree of spatial and temporal variability in rainfall. In the Humboldt River Basin overall, annual precipitation levels vary from 6 inches (15.2 cm) in the valleys to more than 45 inches (114.3 cm) at higher mountain elevations (Horton 2000). Snowfall in Elko County averages 42 inches (106.6 cm) annually (U.S. Climate Data 2018) but is also highly variable year to year. Runoff from mountain snowpack is the main water source that feeds streams in spring and summer (Horton 2000). These climatic and vegetation conditions have made livestock grazing a dominant land use in the county since Euro-Americans settled there in the 1860s–1870s (Horton 2000, Starrs 1998) (fig. 2). Although beaver trapping first drew Euro-Americans to Nevada's Humboldt River Basin in the 1840s, trappers were soon followed by miners, ranchers who helped feed them, and the railroad (Horton 2000, Starrs 1998).

Only 25 percent of land in Elko County is privately owned, and 19.4 percent of land in the county is farmland (including ranchland), thus the vast majority of private land is ranchland (USDA NASS 2012). In 2016, the county population was roughly 52,000, with 27 percent of the population over age 16 employed in natural resource-based industries (mining, agriculture, forestry, fishing, and hunting) (Headwaters Economics 2018b). Mining (mostly for gold and silver) is still an important natural resource-based industry in Elko County, with some mining

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Figure 2—Elko County ranching landscape, Mary's River drainage.

companies owning large ranches. Federal and private lands commonly exist in a checkerboard pattern owing to a history of transcontinental railroad land grants. This checkerboard ownership pattern means that grazing strategies are planned and implemented across property boundaries.

Fifteen of the 21 ranchers interviewed for this study were associated with 10 family-owned ranches, of which six are multigenerational family ranches. Four ranchers interviewed managed or leased ranches owned by one of two mining companies. Two ranchers managed ranches owned by absentee owners who work in other economic sectors and keep their ranches for recreational or investment purposes. All these ranching operations are economically self-sustaining businesses. Mining companies in Elko County own ranches to obtain access to land, minerals, and water, as well as land management and mitigation opportunities to offset the environmental impacts of mining. Most ranching operations are cow-calf operations, though a

few also produce yearlings; one ranch was mainly a sheep operation, and another had goats. All ranches also have horses that are used for herding cattle, though one also keeps horses as part of a recreation business operating on the ranch. Ranchers typically grow hay in summer to feed their livestock in winter (fig. 3); most use flood irrigation (fig. 4), which influences their relations with beaver.

Ranch size in Elko County tends to be large owing to environmental conditions and the history of how ranching developed there (see Starrs 1998). Of the 11 ranches for which I gathered data, ranch size ranged from about 22,000 to 952,000 ac (8903 to 385 260 ha), including both deeded lands and federal land allotments. Average ranch size was about 300,000 ac (121 405 ha). However, the average size of a family ranch was 47,000 ac (19 020 ha), while the average size of a corporate ranch was 500,400 ac (202 504 ha). Of this, deeded land typically ranged from 10 to 25 percent of the total acreage, with the remainder being federal land and most often BLM land. Nevertheless, three ranches were 50 to 75 percent private land. Ranchers ran from about 500 to 7,000 mother cows, according to the size of the ranch, with this number fluctuating annually depending on rainfall and range conditions. The large size of ranches in Elko County is significant because many drainages contain only a few ranches, meaning a small number of operators control a large portion of the landscape. Fewer operators controlling larger acreages can make it easier to implement watershed restoration. Fewer operators mean fewer entities to work with on restoration efforts, and fewer neighbors who may manage in ways that compromise the success of those efforts.

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Figure 3—Hay is harvested and baled in late summer to provide food for livestock in winter.

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Figure 4—Hay is typically produced using flood irrigation.

Fish, Grazing, and Beavers in Elko County

The Fish Story

The grazing and beaver stories in Elko County began in the 1970s as a fish story. The Lahontan cutthroat trout *(Oncorhynchus clarkii henshawi)* (fig. 5) was federally listed by the U.S. Fish and Wildlife Service as endangered in 1970 and reclassified as threatened in 1975, which it remains today (USDI FWS 1995). The Lahontan cutthroat trout is endemic to large freshwater and alkaline lakes, rivers, and streams in the Lahontan Basin of northern Nevada, northeastern California, and southeastern Oregon. Today, Lahontan cutthroat occupy only about 8.6 percent of their historical stream habitat range and less than 1 percent of their historical lake habitat (USDI FWS, n.d. a). Many variables contributed to its decline, including hybridization with nonnative species of trout; competition with introduced fish species; habitat loss and degradation from logging, mining, urban development, and livestock grazing; water diversions and dams; poor water quality; altered stream channels and morphology (USDI FWS 1995); and more recently, drought (NDOW 2004). Regarding livestock grazing, key impacts occur from concentrations of livestock in riparian areas—especially in summer and early fall—causing streambank alteration, reduced vegetation cover, stream channel exposure,

Jason Barnes

Figure 5—Lahontan cutthroat trout from Summit Lake, Nevada.

increased silt loading, and altered stream morphology (wider, shallower streams) resulting in higher summer water temperatures and colder winter temperatures (USDI FWS 1995).

The species management plan for the upper Humboldt River drainage basin (NDOW 2004) identifies habitat management as a priority action to promote Lahontan cutthroat trout recovery in Elko County stream systems. These include Maggie Creek, Susie Creek, Rock Creek, and Mary's River. The Humboldt River Basin has been heavily affected by livestock grazing since the late 1800s, resulting in extensive damage to vegetation, soil erosion and gullying, reduced capacity of soils to hold moisture, and the spread of exotic weeds (Horton 2000, Starrs 1998). The first half of the 20th century saw efforts to reduce livestock numbers and manage livestock grazing. However, the ecological and hydrogeomorphic effects of grazing practices that prevailed from the late 1800s through the mid-1900s persist today (Horton 2000).

In the Humboldt River Basin, 67 percent of Lahontan cutthroat streams flow through Forest Service lands and 49 percent flow through BLM lands, where livestock grazing is the dominant land use. Thus, the plan directs both the

Forest Service and BLM to improve riparian habitat for the trout. The goal is for streams with current populations, or potential habitat where fish could be reintroduced, to achieve proper functioning condition that enables viable populations of the species to recover. This includes managing livestock grazing in watersheds and streamside management zones on federal lands to promote desired habitat conditions. In 1996, the Fish and Wildlife Service, NDOW, and BLM developed a memorandum of agreement recommending livestock grazing guidelines (NDOW 2004).

One other listed fish also occupies the study area. Interior redband trout (*Oncorhynchus mykiss gairdneri*) is listed as a species of concern under the Endangered Species Act, and as a BLM sensitive species (fig. 6). This species is threatened by habitat loss and fragmentation, population isolation, and hybridization with other trout species (USDI FWS, n.d. b). The BLM and U.S. Forest Service are partners in a multi-stakeholder conservation agreement to sustain interior redband trout within its historic range. This species, present in the Salmon Falls Creek drainage, also stands to benefit from improvements in grazing management.

Daniel Dauwater

Figure 6—Interior redband trout from the Salmon Falls Creek drainage.

The Grazing Story

The BLM, which manages 63 percent of the land in Elko County, has been the main initiator of grazing changes on federal lands. Ranchers and agency employees interviewed described the federal lands grazing system that prevailed until the 1980s. Cattle were typically turned out onto allotments in March or April, and rounded up to return to private lands sometime between October and December. Allotments are large (more than 200,000 ac [80 937 ha] in some cases) with perimeter fencing but little interior fencing. Livestock more or less drifted on their own to find forage and water. That meant that riparian areas were subject to season-long grazing, and during summer months, cattle stayed on the creeks to be near water, green forage, and shade. As one federal agency employee said:

> The traditional Nevada cattle operation, by around the first part of July, the cows are camped out on the creeks. That's typically where they'll be, from July through … the end of the season, when things start to cool off in the fall…. Cows tend to like to sit on the riparian areas, the stream areas, during the summer months (interview 8).

One rancher interviewed had a similar description: "The old-style stuff was, you turn the cattle out and you went to hay, and you forgot about what you were doing out there. Then you went out at some point and got 'em" (interview 20). Consequently, as another rancher stated, "For years, riparians, the creek bottoms really were almost thought of as sacrifice areas" (interview 2). In essence, plant communities did not have enough time to rest and recover from grazing impacts, and riparian areas were denuded.

Beginning in the mid to late 1970s through the 1980s, the BLM addressed stream restoration by constructing some grazing exclosures along riparian areas on grazing allotments. However, the Elko County "project" began in earnest only in the early 1990s, and was a process of changing grazing management in riparian areas to promote watershed restoration. Training workshops offered to ranchers and agency personnel in Elko during the 1990s by the National Riparian Service Team and the University of Nevada, Reno, as well as courses in holistic management (Savory and Butterfield 2016), were important motivating factors for changing grazing management to achieve proper functioning condition in riparian areas. The BLM has focused on improving riparian conditions along priority streams identified in the Elko District resource management plans, including key Lahontan cutthroat trout streams. The Forest Service has participated on some of its allotments with permittees motivated to try innovative practices.

Changes to grazing have focused on reducing the frequency and duration of hot-season grazing (roughly mid-June to late September) in riparian areas so that plants can grow and recover during that time. A variety of approaches have been taken depending on the allotment and permittee. During interviews, I asked ranchers who had adopted these new practices to describe them (table 1). Although the approach varied by rancher, most used some combination of the practices listed, and some may have used, but not mentioned, listed practices—thus indicating wider use than table 1 suggests. These grazing practices and others designed to maintain and restore riparian areas in Elko County, with relevance for rangelands elsewhere, are described in more detail in Swanson et al. (2015).

The new grazing practices were guided by a few core operating principles. First, each allotment was treated differently, because of differences in environmental conditions on each allotment, and differences in the capacity of permittees to undertake changes in their operations. Federal agencies worked with individual

Table 1—Grazing practices used to avoid hot-season grazing in riparian areas and promote their recovery

Practice	Number of ranchers reporting[a]
Adopt rotational grazing through different pastures	10
Use range riders to manage cattle movements within and between pastures, and keep them out of riparian areas	9
Change the timing of rotation through pastures annually so as not to graze the same place at the same time for the same duration each year, limiting grazing impacts during the growing season	8
Allow at least one pasture to rest each year for 1 to 2 years	8
Install interior fencing to create more, smaller pastures	7
Develop alternate sources of water (generally in uplands) to keep cattle away from creeks	6
Rest pastures for a few years initially to begin the recovery process	4
Allow grasses to mature and produce a seed head before grazing them	4
Subdivide pastures and practice short-duration, high-intensity grazing, sometimes with use of electric fencing	2
Voluntary destocking during drought years	2
Install riparian corridor fencing with water gaps to keep livestock out of riparian areas	2
Use salt licks and/or mineral supplement tubs to draw cattle to desired locations, away from riparian areas	2
Irrigate meadows on private lands so that cattle can graze there during the hot season, away from riparian areas	2
Fence off riparian pastures that are grazed for only a few weeks in spring or fall	1
Limit use of riparian pastures to spring and fall, when animals' water and shade requirements are lowest, so that they are not compelled to use riparian corridors other than to drink	1

[a] In some cases, two interviewees described practices occurring on the same ranch; these were tallied as two.

permittees to see what strategy might work best for a person on their particular ranch and allotment. The goal of improving proper functioning condition in riparian areas was the same for each allotment, but how to get there differed depending on the permittee. As one BLM employee stated:

> …for me, personally, it was about taking advantage of opportunities. It's what the rancher can do, and everybody's got a different allotment. They have a different operation. They have different limitations…. The goal is just to reduce that frequency and duration of hot-season grazing (interview 4).

A second core principle was to avoid traditional solutions that had proven ineffective in the past. One such principle was to reduce the permitted number of livestock on allotments. Permit numbers had been cut several times since the early 1900s to correct overstocking of sheep and cattle that occurred in the late 1800s and early 1900s. But none of the ranchers interviewed reported reducing their herd sizes or animal unit months (AUMs)[1] on federal grazing allotments to improve riparian conditions. One rancher explained why:

> "They try to destock, but that has no effect, because no matter how many animals you have, they all camp down in the riparian area, and the riparian areas don't have any time to recover from utilization" (interview 10).

Another traditional solution that was avoided was to manage by conventional grazing standards such as stubble height and stream bank alteration. As one BLM employee stated:

> I've purposely and strongly steered away from trying to manage grazing by things like stubble heights and trampling…. It's one tool in the toolbox, but it's probably one of the weakest… streams can take impacts. It's just you can't do it all the time. If you set things up to where you can have periodic impact, it gives you more flexibility for the bigger picture… what's really improved these streams is the rotation, is moving that impact around through time and space. That's really what it is (interview 4).

Moreover, managing by stubble heights and stream bank alteration requires a level of agency oversight for monitoring and measuring that is unrealistic given current staffing levels.

[1] Grazing permits on Bureau of Land Management and U.S. Forest Service lands specify the number of animal unit months (AUMs) a permittee can use. One AUM equals the amount of forage a mature cow and calf consume in a 30-day period.

Federal agency interviewees believed they were getting the same outcome as they would by imposing conventional grazing standards, but just getting there using a different approach. One BLM employee explained:

> We simply cannot—we are not staffed, at any sort of a level that allows us to have that level of direct observation, hardly anywhere on our district. That's why we have tried to get at basically the same place, but by using prescriptions on duration of use, season of use… that have actually proved to us, by putting them in a lot of different places, that we can improve riparian conditions by putting these riparian-friendly systems in place, but not necessarily incorporating all of these you will have 4 inches of stubble height, or 10 percent streambank trampling, and then your cows have to go. We're getting to the same place, but we're coming at it from a different way (interview 8).

A third core principle that developed over time was flexibility to allow for adaptive management. In the 1990s, when the BLM became more proactive in managing to improve riparian conditions, changes to grazing management on allotments were often made via formal grazing decisions and plans. For example, mining companies with allotments were in a unique position to improve stream and riparian habitats through support for progressive riparian grazing management as mitigation for dewatering associated with mining activities. Although the ensuing plans brought about improvement, such plans did not allow much flexibility. Elsewhere in the 1990s, a few ranchers were experimenting with holistic management, and worked with the BLM and Forest Service to develop permit terms that would enable them to do so. It was in the 2000s, however, as more ranchers became interested in improving stream conditions, that the agencies increased their efforts to create flexibility within existing grazing permits to improve grazing management. This flexibility enables permittees to move cattle in response to variation in forage and water availability season to season and year to year. One BLM employee described this as follows:

> Honestly, we did do a lot of grazing systems in the early '90s, and we learned a few things over time, and we especially learned that we should've been more flexible. The way the government processes work, once you get something in place, it's hard to go back and make it more flexible. That's a lesson that we've learned because streams change and what was a conservative system initially may not be necessarily warranted as a system gets more robust. If you're overprotective in one area, you can have too much impact on the next area outside (interview 4).

Flexibility mainly translates into specifying an allotment's on and off dates on the permit (e.g., when the livestock enter in spring, when they leave in fall), but not specific dates for moving them from pasture to pasture. The permit also specifies the number of AUMs that are allowed on the allotment, but the way in which the permittee chooses to use those AUMs is open. The main thing that ranchers didn't want on their permits was specific dates associated with specific pastures that are hard move dates in and out of those pastures, and specific AUMs for each pasture. These prevent flexibility in movement, timing, rotations, and intensity of use. Of course, flexibility works best when permittees are responsible and do not take advantage of this openness, as one BLM employee explained.

> If we don't have a set grazing system on a permit, that means the permit's open ended, and there's a lot of flexibility if they're open ended. That could be really bad [if ranchers did not graze responsibly]. With these progressive ranchers, it's really good because they have this wide latitude. There's a lot of flexibility in that wide latitude (interview 4).

For their part, ranchers expressed appreciation for the BLM's willingness to be flexible about how they reached the desired outcomes.

> …here's a BLM office that … says, "Hey, yeah. We need to find solutions. We need to figure out ways to work with you guys, not against you guys, because we can't do it." This whole let's regulate the tar out of everybody and create all these policies, that doesn't work. We know that. It fails all the time, because you can't—our landscape is too dynamic (interview 3).

Fourth, monitoring was employed to document outcomes of grazing management in riparian areas. Several studies have taken place over the years that employ photo point monitoring and analysis of aerial and remote sensing imagery to evaluate changes in riparian conditions (see app.). These data demonstrate that the grazing management changes occurring in Elko County are having a substantial impact, which helps garner support for them among ranchers and agencies alike (fig. 7).

Figure 7—Photo point monitoring at stream station S-4 on Susie Creek, Bureau of Land Management [BLM] Elko District Office, 1989–2017. (A) September 18, 1989 after grazing by cow-calf pairs annually throughout the growing season and the summer months (Carol Evans, BLM). (B) July 5, 1994 after grazing changed in 1992 to mostly late fall use. Willows start to recover, no beaver are present (Kelly Amy, BLM). (C) June 11, 2003 after grazing by cow-calf pairs or dry cows mainly in September and October since 1992. Beavers have begun to colonize the area (Carol Evans, BLM). (D) September 8, 2017 after grazing by groups of about 200 cows for short periods between September and October since 2007. Cow-calf pairs are gathered from surrounding allotments, calves are removed, and dry cows are held for a short period of time in the riparian pasture, then taken home. A new group enters, and the process is repeated. Beavers are well established. (Carol Evans, BLM).

The Beaver Story

In Nevada, beavers occur mainly in the northern part of the state (Pollock et al. 2017). Prior to initiating changes in grazing practices, ranchers and agency personnel interviewed concurred that there were few if any beavers on ranches in Elko County. They attributed their absence to degraded creeks, lack of vegetation to create habitat, and trapping on some ranches. Interviewees also observed that since the 1990s, beavers had been increasing in number and expanding their range. The NDOW does not survey beaver populations, but biologists interviewed reported that beavers have been repopulating northern Nevada, and are currently found in every major watershed north of Highway 50. Localized populations may fluctuate, depending on conditions, but overall, beaver populations appear to be on the rise.

Some interviewees identified decreased trapping pressure for the commercial fur trade as one factor in the spread of beaver in Elko County. Beaver trapping has decreased slightly in Nevada since 1990 (fig. 8). Beaver trapping in Elko County in recent years (the only ones for which we could obtain data) also declined (from 286 pelts in 2012–2013 to 46 pelts in 2017–2018) (fig. 9). The number of beaver trappers dropped from 24 in the 2012–2013 season to 10 in the 2017–2018 season (fig. 9). These decreases are likely due to the low price for beaver pelts, which averaged $13.75 per pelt at the Fallon, Nevada, fur auction between 2008 and 2018 (Nevada Trappers Association 2018). An NDOW employee interviewed surmised that most of the beaver trapping currently occurring in Elko County is for the purpose of removing nuisance beavers, or obtaining a pelt for personal use.

However, most interviewees believed the main explanatory factor was the creation of favorable habitat conditions, an outcome of changes in grazing management that has led to stream restoration. As riparian vegetation recovers from the impacts of hot-season grazing, woody plants such as willow develop, and stream conditions stabilize. Then, beaver move in. One rancher expressed it this way:

> …you start to get some willow growth, and as you get willow growth beavers naturally started to occur. They were probably close, or there was probably a couple hiding out that not many people knew about. You don't know where they were living … Who knows? We all know they travel over land significant distances, so they show up as soon as you have the habitat. As soon as you build it, they show up (interview 2).

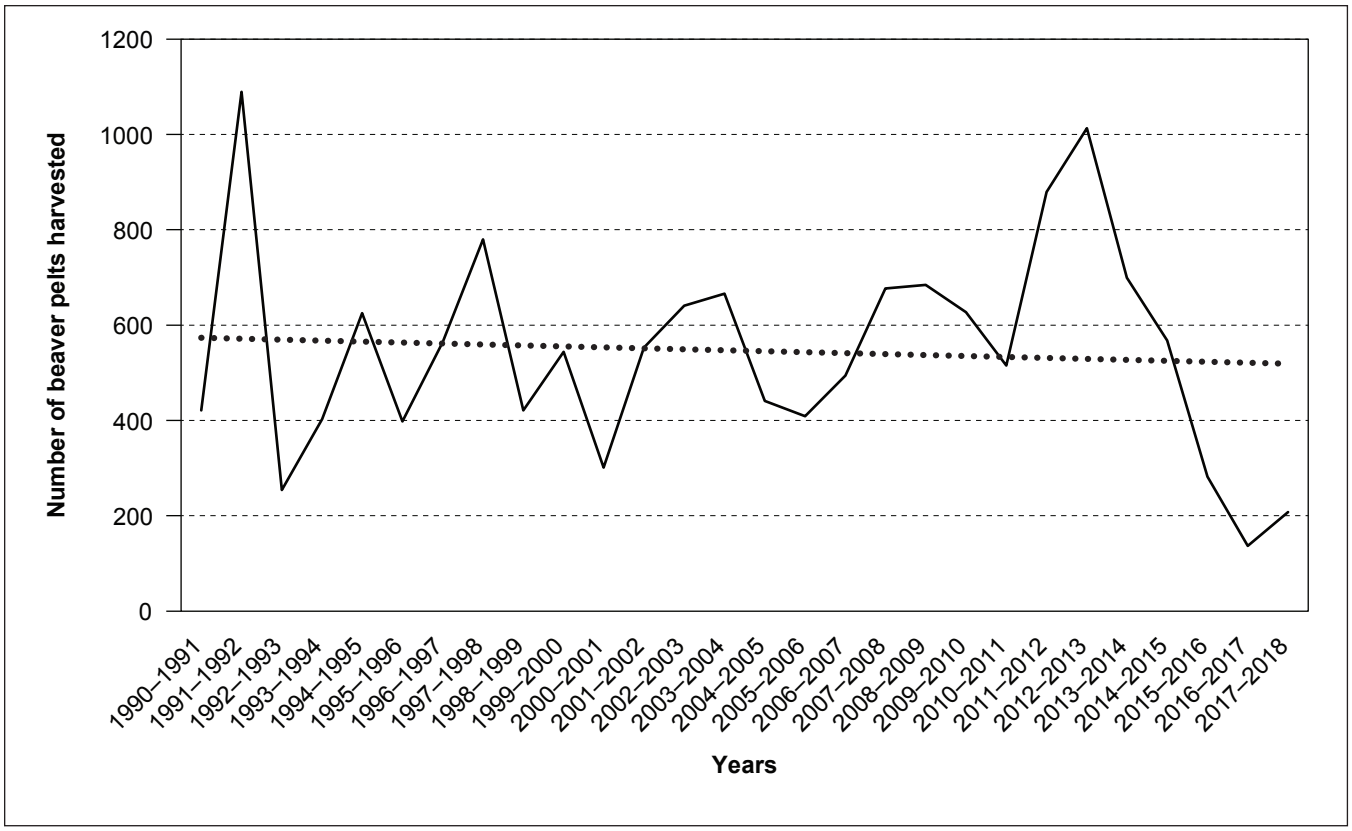

Figure 8—Nevada beaver pelt harvest, 1990–2018. Source: NDOW 2018.

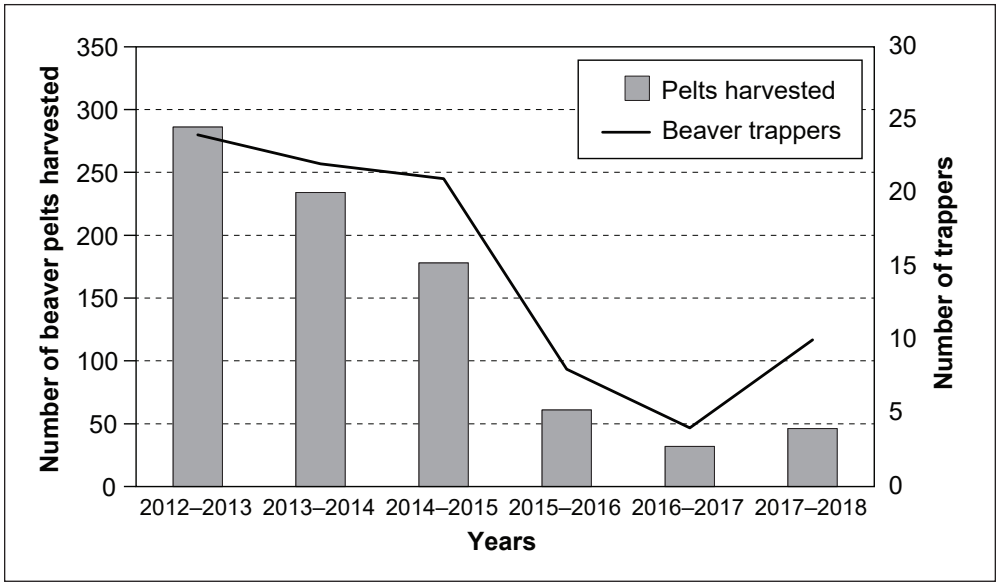

Figure 9—Beaver pelt harvest in Elko County and number of beaver trappers, 2012–2018. Source: NDOW 2013, 2014, 2015, 2017, 2018.

Monitoring data support these observations. Time series photos of select drainages in Elko County document significant changes in riparian vegetation on grazing allotments since the early 1990s when the grazing system began to change (see photos in Swanson et al. 2015 and fig. 7). Monitoring studies based on analyses of remote sensing data and aerial imagery also reveal increases in riparian vegetation on allotments along creeks that run through grazing allotments in Elko County (Fesenmyer 2016, Fesenmyer et al. 2015, Open Range Consulting 2015, Simmonds and Sant 2011, White Horse Associates 2011). Some of these studies also documented the increase in beaver populations that accompanied these vegetation changes (table 2). As beaver colonize and build dams, they contribute to the vegetation recovery process (Fesenmyer et al. 2018).

The beaver story is one of natural colonization. Interviewees reported two different attempts at beaver translocation that occurred in earlier decades that were unsuccessful. The NDOW interviewee viewed translocation as too costly and challenging with a low likelihood of success. Interviewees also viewed it as unnecessary, since beaver have been increasing on their own. The same is true of artificial beaver dam construction, which has not occurred in Elko County, except as part of a training class sponsored by Utah State University and the Natural Resources Conservation Service in August 2018. Most interviewees were of the view expressed by this rancher: "… you can spend great big gobs of money doing that kind of stuff, and I see no point in it. I think if you have the habitat, you'll get beaver—at least in my experience" (interview 6).

Table 2—Increases in active beaver dams on public and private lands in select Elko County locations based on remote sensing studies

Location	Change observed	Source
Carlin allotment (Susie Creek)	1991: 0 dams 2013: 96 dams	Fesenmyer et al. 2015
Hadley allotment (Susie Creek)	1991: 0 dams 2013: 12 dams	Fesenmyer et al. 2015
McKinley allotment (Susie Creek)	1991: 0 dams 2013: 31 dams	Fesenmyer et al. 2015
Humboldt (Squaw Valley) allotment (Rock Creek drainage)	1978: 19 dams 1998: 8 dams 2003: 30 dams	Open Range Consulting 2015
T Lazy S, Twenty-five, and Hadley allotments (Maggie and Beaver Creeks)	2006: 107 dams 2010: 271 dams	White Horse Associates 2011
Canyon, Cottonwood Creek, and Hubbard Vineyard allotments (Salmon Falls Creek drainage)	1995: 32 dams 2013: 192 dams	Fesenmyer et al. 2016

Several interviewees believed that natural colonization by beaver would occur in Elko County's watersheds if compatible grazing practices are in place: "You have to get the grazing right to support the beaver. You can put all the beaver and analogs in there you want, but if you've got a grazing problem, it's not going to work. You have to change the grazing, which brings in the willows" (interview 4).

Enabling Factors for Changing Grazing Management

The fish-grazing-beaver story in Elko County makes clear that changing grazing management was key to beaver colonization and watershed restoration. Because so much of Elko County consists of federal lands, this meant that both federal agency staff and ranchers had to work together to achieve desired outcomes. Thus, many of the factors that enabled project success revolved around the ability of ranchers and agencies to implement new grazing approaches. These included (1) a willingness and ability to change on the part of permittees; (2) making riparian restoration a priority on federal lands, taking measures needed to manage grazing in riparian areas, and building in flexibility over time to facilitate new grazing management approaches; (3) collaboration among agencies and ranchers to make these changes; (4) agency employees who remained in the same office for years and built good working relationships and trust with local ranchers; and (5) scaling up by example, i.e., having successes that other ranchers could see during site visits.

Permittee Flexibility

Interviewees acknowledged the difficulty of changing grazing management practices, especially when the old system worked well for a livestock operator. Several permittees commented that they had to change their mindset in order to change their grazing practices, and it was hard. One rancher said, "Open mindedness is a key… . It's easy to get stuck in what we think our normal is and what we think our 'as good as it gets' is…; getting outside of that is a good thing" (interview 6). Although many project participants believed that the changes in grazing management had benefitted their ranching enterprise and the environment, it can be risky to do things differently. Some permittees have more flexibility than others to do new things, depending upon their resources (e.g., finances, labor). For example, a mining company that has extensive financial resources and an incentive to undertake restoration in order to offset mining impacts is more likely to be able and willing to change past practices than a small family rancher.

Incentive systems for improving grazing can help. One example is the Nevada Conservation Credit System, established in 2013 to promote habitat conservation for greater sage grouse *(Centrocercus urophasianus)* (NDCNR SEP 2018). Mining

companies that own ranches are particularly interested in this system because it offers an opportunity to engage in restoration activities that offset the loss of sage grouse habitat from mining activities. Some family ranchers interviewed also expressed interest in generating credits for sale under the system by restoring sage grouse habitat on their properties. Implementing adaptive grazing management, and protecting or increasing wet meadows, qualify as activities that can generate conservation credits because they benefit sage grouse habitat (NDCNR SEP 2018). Mesic habitat is especially important for brood rearing by sage grouse (Donnelly et al. 2016). Because beavers promote mesic habitat, they can also contribute to sage grouse conservation.

Agency Flexibility

Willingness and flexibility on the part of federal agencies to let permittees try new management approaches was also critical. As one interviewee said, "…you can't make this happen without flexibility" (interview 2). An example of this flexibility is to give permittees broad sideboards on their permits so that they can graze in a manner that meets mutual ecological and economic objectives, and focuses on outcomes rather than grazing prescriptions. Permits typically specify the number of AUMs that can be grazed, on-off dates, and dates for moving to and from specific pastures within allotments. Some permits are more flexible than others, i.e., movement dates are not as specific. Most permittees did not take issue with the number of AUMs specified on their permits. But those having less flexible permits felt that the lack of flexibility did not enable them to graze in the most ecologically appropriate way. Nor did it enable them to respond appropriately to natural disturbances such as fire, invasive plants, and drought. They did, however, try to work within their permits to make required changes to range management, and the BLM and Forest Service also tried to be more flexible.

Grazing permits are supposed to be renewed every 10 years. When a permit is renewed, it is possible to rewrite the terms of the permit and add in more flexibility. However, the BLM and Forest Service are generally unable to accomplish permit renewals in a timely way. Permit renewal requires doing a National Environmental Policy Act (NEPA) analysis. Agencies often don't have the capacity to undertake the analysis because of cumbersome workloads, insufficient resources, and other NEPA analysis priorities (e.g., related to sage grouse). Thus, permits often simply roll over for another 10 years, with the previous terms—such as having the same number of AUMs in the same pasture for the same amount of time every year. Of course, some ranchers prefer to keep doing things the same way. Others who think a change will produce a better outcome are left frustrated. One rancher described the problem this way:

> There's a lot of management plans that are set up for the same time and timing every year with the same intensity every year. We look at the science now and say, "Well, that doesn't really work for ecological development," but you're still handcuffed to this permit that says 500 cows June 1 to June 30…. Every year is different as far as vegetation, as far as springs. How much winter [precipitation] did we get? How did those plant communities respond? That's what the grazing permit needs to be tied to, and not "here's dates from 1970" (interview 5).

Changing grazing management to reduce hot-season grazing in riparian areas also required some infrastructure improvements, e.g., new fencing and upland water developments to provide alternate places for livestock to drink. Funding for infrastructure improvements was not a limiting factor. Often funds were contributed through partnerships among federal and state agencies, the nongovernmental organization Trout Unlimited via grants from the National Fish and Wildlife Foundation, and mitigation funds from mining companies. However, water development on Forest Service or BLM lands also triggers the NEPA process (depending on the nature of the proposed development). The NEPA process requires time and resources, can be a barrier to new water development, and can take years. Further complicating the problem is Nevada's system of water rights. If agencies want to create new water developments on federal lands they may be required to apply for a water right. Most ranchers have gotten around this problem by developing water sources for cattle on their private lands that are intermingled with federal land.

Collaboration

Ranchers and agency staff have tried to implement grazing changes by taking a collaborative approach, as described by one BLM employee:

> It works a lot better if we can sit down with the permittee and say, "you know what? We have to change things. What can you do? This is what we're looking for, in the end. What can you do that can ensure we get there?" Versus BLM coming in and saying, "this is what you're going to do." The buy-off is a lot better (interview 8).

A rancher agreed: "Really, really good people I'm fortunate to work with … didn't come at me with a bat, came at me with a handshake and said, 'Hey, can we do something different here? What can you do here to make this better,' asking me questions instead of beating me up over it" (interview 6).

Building positive collaborative relations between ranchers and agency staff has not been the only important factor; building collaborative relations among ranchers and other stakeholders has been important as well. For example, landowners,

agency resource specialists, and users of federal lands have formed the Stewardship Alliance of Northeast Elko (SANE) group to promote livestock grazing practices that conserve habitat for the greater sage grouse, while enhancing the viability of ranching operations across 1.7 million ac (687 965 ha) of public and private lands (SANE 2014). Collaborative groups such as this make it possible to learn from each other what works and what doesn't, what is possible, to support one another, and to promote buy-in from multiple stakeholders.

Long-Term Agency Employees

Integral to the success of local collaborative efforts to change grazing management on federal lands has been agency employees committed to the process who have remained in their jobs, in the same local agency offices, for years. As one agency employee observed, "…we've all been together for a long period of time. That's absolutely key. I think, with turnover, it just wouldn't have happened. It's hard to do this stuff if you're only in place a couple of years…" (interview 4).

Long-term commitment to place has built working relationships and trust among participants. Not all permittees have the same flexibility in their grazing permits. The agency can benefit from trusting permittees to do the right thing if it gives them more leeway, and permittees can benefit from trusting the agency not to come down too hard if some of the experimentation does not at first deliver the hoped for results. As one rancher reported, "I made mistakes. Fortunately, those things heal up fast, and you get past it, but it would've been easy for somebody to say, 'Oh, that's it,' and she never did. She stuck with me. That's a key" (interview 6).

Ranchers were also concerned about agency turnover from the standpoint of not knowing what the next agency employee in charge of grazing decisions would be like. Different agency employees make different decisions. There's a fear that with turnover among agency staff, "…we could really be jerked back to those old dates and those old things…" (interview 2).

Building on Success

Finally, it has been important to have successes on some ranches that other local ranchers can see during site visits to demonstrate that it's possible to have management that benefits both livestock and the environment. One agency interviewee emphasized that the message about change should come from someone in the ranching community rather than the agency. "I think the ranchers telling this story is really powerful. It needs to come from the ranchers" (interview 4). The same agency employee commented on a tour that occurred of three different ranches the preceding summer: "a bunch of ranchers came … and that was the height of our drought in August, year four of the drought, and there's all these productive wetlands with ducks. It sells itself when you do that" (interview 4).

Consequences of Beaver Colonization

Interviewees observed numerous hydrogeomorphic and ecological changes that they attributed to beaver colonization in Elko County during recent decades (table 3). The most commonly reported changes pertained to the spatial and temporal distribution of water, both of which have increased. More water in streams, available later into the dry season and during drought years, has been a noticeable change that all viewed as positive. As one rancher said, "…if you get water in this country you've got everything" (interview 12). Another echoed this sentiment: "In my vote, a beaver equals water storage, and water storage equals better everything. You can't argue water storage in the desert" (interview 16). Ecological changes associated with beavers and their dams observed by interviewees included the areal expansion of "green zones" around riparian areas, with increased wet meadows and riparian vegetation and decreased sagebrush. These increases, in turn, were observed to benefit wildlife and increase biodiversity. A few interviewees had seen the ecological changes that beaver brought about unfold over a period of 15 to 20 years. This process began with the growth of riparian vegetation, then beaver arrival and landscape alteration, and eventually depletion or flooding of beaver food

Table 3—Hydrogeomorphic and ecological consequences of beaver colonization reported during interviews for this study (n = 21)[a]

Outcome observed	Number of interviews
Hydrogeomorphic:	
Increased water availability in streams and beaver ponds, and longer duration of stream flows, during the hot season	16
Higher water tables and increased groundwater storage	14
Increased instream soil deposition behind beaver dams	6
Dams slow down and spread out stream flows/runoff during large storm events, reducing flooding	5
Some previously intermittent streams have become perennial	4
Reduced streambank incision and erosion	3
Ecological:	
Expansion of riparian areas and meadows (the "green zone"), and an increase in wet meadows over the longer term	10
Increased biodiversity in riparian areas, and wildlife benefits	8
Increased growth of riparian vegetation	5
Cut down trees	5
Improvements in instream fish habitat conditions, benefiting fish	4
Sagebrush die off in riparian areas	4
Increase in nesting and rearing habitat for sage grouse	2
Better watered streams and riparian areas serve as fuelbreaks during wildfire	2

[a] The one interview not reporting hydrogeomorphic or ecological outcomes from beaver colonization was one in which the respondent was not asked, owing to the interview's focus on water regulations.

sources, with vegetation changes causing beaver to eventually move away, leaving wet meadows behind that were not there initially.

Research and monitoring data support these observations (see app.). Several studies identify changes such as increased surface water, higher groundwater levels, improved stream conditions, and increased riparian vegetation that are at least partially attributable to the increase in beaver dams that has occurred in Elko County stream systems since the early 1990s. Additionally, research from Elko County and watersheds in southeastern Oregon documents the positive response of riparian vegetation along low-gradient streams to a combination of conservation grazing practices and beaver dam development, with benefits for fish and wildlife (Fesenmyer et al. 2018). These documented changes are consistent with the observations of interviewees.

Endangered fish were the initial impetus for changing grazing management. Studies of the impacts of beaver dams on Lahontan cutthroat trout and interior redband trout are lacking. However, scientists have conducted long-term monitoring of Lahontan cutthroat trout demographics and genetics in Maggie Creek (Neville et al. 2016). They found that stream restoration resulting from changes in grazing management, combined with improving fish habitat connectivity by replacing road culverts and modifying an irrigation diversion that blocked fish passage, have had positive impacts. These include evidence of fish movement among streams and into mainstem habitat, increased fish density (though not genetic diversity) in some tributaries, and a greater number of large, migratory-sized adult fish.

Ranchers, Livestock, and Beavers

The hydrological and ecological changes that have occurred in Elko County since grazing practices changed and beaver took up residence have had an impact on livestock, ranchers, and their ranching operations (fig. 10). Almost all ranchers and agency personnel interviewed offered observations on how beavers have affected cattle and ranching operations, and vice versa. There were no reports of interactions between beavers and sheep, because sheep generally graze at higher elevations and on steeper terrain than cattle, where stream gradients are not conducive to establishment of beaver populations and dams. No interviewees reported any direct negative impacts of livestock on beaver or their dams (although most acknowledged the relationship between overgrazing in riparian areas, lack of vegetation, and absence of beavers). As one rancher put it, in response to a question about whether cattle were hurting the beavers and their dams: "…no, no, no, if that were the case, we wouldn't need to go buy dynamite" (interview 6). In the past, dynamite was used to remove unwanted beaver dams.

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Figure 10—Beaver dam on a ranch in the Salmon Falls Creek drainage.

Interviewees reported both positive and negative impacts of beavers and their dams (table 4). Most notably, interviewees felt that the increased water availability for livestock in the hot season and during drought years was extremely beneficial, as were increased quality and quantity of forage in riparian pastures. Both of these benefits improved livestock condition and may translate into financial benefits for ranchers. One rancher responded to a question about the role beavers had played in streamflows as follows:

> I give them all the credit. Yeah, we had to build them suitable habitat or let the habitat be suitable for them, but they did the heavy lifting. They did all the work. I'm sure that most years, without beaver, Susie Creek probably would've ran, but I'll bet you the last two or three it wouldn't have (interview 6).

Table 4—Impacts of beavers on livestock and ranchers described by interviewees

Impacts	Number of interviews
Positive:	
More water is available for livestock to drink later into the hot season and during drought years.	17
Meadows/riparian pastures have expanded and forage production there has increased; there is more green forage available later into the hot season; there is more green forage at higher elevations where cattle can graze later into the hot season; all of this improves livestock health.	12
Increased forage production means cattle have more feed, gain more weight, and eat less hay, creating financial benefits.	2
More water available later into dry season reduces the need for ranchers to haul water for livestock, creating financial benefits.	2
Increased water and forage availability make high-intensity, short-duration grazing practices more successful because grazing intensity can increase, and pastures can recover better.	2
When water backs up behind beaver dams and overflows onto hay fields, there is natural irrigation, reducing the need for intentional irrigating.	2
More water and forage mean one can run more cattle on private lands where animal unit months are not limited.	1
Beavers build and maintain water developments for cattle (i.e., beaver ponds), decreasing the workload for ranchers.	1
Increased water availability across the landscape creates more options for where to move livestock when, increasing flexibility of grazing management.	1
Soil deposition behind beaver dams means less sediment flows downstream to private lands and clogs irrigation infrastructure.	1
Beaver ponds provide a hot-season water source that enables firefighters to fight wildfire with helicopters using buckets.	1
Vegetation growth in riparian areas provides more shade for livestock.	1
Negative:	
Beavers interfere with irrigation infrastructure and plug it up, impeding the flow of water.	11
When beaver dams back up water or beaver block culverts, roads and trails can flood and wash out.	6
Livestock cannot cross creeks where beaver dams are located, so must be driven further up or downstream, creating more work.	6
When beaver cause riparian pastures to become too wet and muddy, cattle may be unable to graze there. If cattle do graze there, it is hard to move them out because crossing wet meadows on horseback is difficult, and animals may get stuck in the mud.	6
When beaver dams promote growth of dense riparian vegetation such as willows, cattle can get lost and are more difficult to gather; vegetation may also become too thick for cattle to penetrate, and reduce available forage.	5
Beaver cut down trees such as quaking aspen and cottonwood, which people like for aesthetics and shade, and which reduces shade available to livestock.	5
Sometimes beaver eat themselves out of house and home, stripping riparian areas of vegetation, which can have negative ecological impacts, especially if livestock grazing is limiting regeneration.	2
Cows can get stuck in beaver ponds, or wallow in the mud around them, or fall into them when they ice over in winter, and become injured.	2
Beaver dams back up water and flood hayfields, which is bad for hay production if fields become too wet.	2
Beaver ponds cause water flows to slow down, meaning that in winter, beaver ponds and slow running creeks are more likely to ice over; this reduces open water for watering livestock.	1
It is harder to maintain riparian fencing when beavers make the ground more muddy and marshy.	1
Beaver dams can cause river water to flow around their sides, causing an increase in streambank erosion.	1

Another rancher explained the benefits of beaver this way:

> You have more water. You have more weight. You have more options, as far as that mountain dries up, you've got somewhere to go. You always want to be—ranching's kind of like a chess game. The fact that you want to think a lot of moves ahead, as far as cattle and where to go (interview 5).

On the downside, ranchers stated that beaver dams can cause flooding of roads and trails, impediments to crossing creeks, muddying of riparian pastures, and an increase in vegetation that hides livestock, which are detrimental to their operations. The biggest drawback, however, is beavers' impact on irrigation infrastructure. Ranchers typically grow hay in summer to feed livestock in winter, and do so using flood irrigation. Beavers create a nuisance when they block irrigation canals and impede the flow of water.

In 2015, the Seventh Generation Institute, based in New Mexico, held a workshop in Elko County to educate ranchers about techniques for mitigating the negative impacts of beavers. These techniques included installing flow devices in streams to keep beaver from blocking water flows (fig. 11). Although few ranchers in Elko County have adopted such mitigation measures, they do exist and can help alleviate the problems beavers cause.

Some interviewees perceived only benefits from beavers and their dams, but most perceived both benefits and drawbacks. Regarding drawbacks, these were often geographically localized; interviewees felt that beavers in the "right" location are beneficial, but in the "wrong" location are destructive. Frequently, the right location was on federal lands and the wrong location was on private lands having irrigated fields and pastures.

> Even the most progressive operator, if you've got a beaver who starts coming in and plugging up all of your irrigation ditches, or messing with a lot of that kind of infrastructure, that's not going to work. There's a difference there between the beavers that start doing that, and beavers that are doing their thing just out on the open range (interview 8).

Most agreed, however, that the benefits of beavers outweigh their drawbacks. In response to a question about the impact of beavers on grazing management and ranching operations, the vast majority of interview responses reflected sentiments such as, "Would I rather have water throughout the range? Yes. Do you have some problems? Yes. There's always a need to recognize the give and take of any activity, and [the net benefit is that] it's a great benefit for us" (interview 10).

Several ranchers also described how their attitudes toward beavers had evolved over time as a result of observing how beavers affect their ranching operations. One rancher echoed others in describing his approach to beavers a few decades ago, when he was younger:

Susan Charnley

Susan Charnley

Figure 11—Some ranchers have begun to install devices that help mitigate the negative impacts of beaver: (A) A flow device on the Winecup Gamble Ranch prevents beaver from blocking water flowing under a bridge and flooding a road crossing; (B) A "beaver deceiver" prevents beavers from blocking a road culvert.

> …a story a lot of us have been through is beavers. I fought them for years because I didn't understand them…. We spent all summer trapping, and shooting, and blowing up dams, and fighting with them, because we didn't understand what they were trying to do (interview 5).

This behavior was common because ranchers generally viewed beaver differently at that time:

> The beaver were the foe. They were holding water back. We need to get that water down to the meadow so that we can irrigate it. We need to kill them. We need to rip the beaver dams out. We need to make long, straight lines so that the water gets here faster. That's the story of how agriculture has progressed…. They trapped the beaver. They were constantly fighting with them. That's what was going on for years (interview 8).

Today, beavers continue to be removed from places they are not wanted by some ranchers, even those who understand their benefits. But perceptions of beavers have changed among many who now appreciate their benefits and view them as an economic asset, and are willing to coexist with them. One rancher described this evolution:

> Let's go back 15 years when I first showed up to [ranch X]: You … crossed a lot of that wet meadow, or boggy places, and past the beaver. Oh, these son of guns got it so screwed up. Okay, that was what you knew then. Fast forward to today; you [have]change[d] how you look at those sites, and you think, 'Wow, this is an amazing piece of water. There's amazing plant communities, riparian plant communities that are here that pack economic value.' I can ride around it. I'll figure it out. You deal with it. Fight the willows, and fight the beaver, and be happy that you're getting to do that and not passing a gravel bar with cut banks and incised channels…. You just ride a little further downstream and cross it, and be glad that's what you had to do, because your cows have water. They have the necessary economic pieces to make your cash flow, as opposed to no habitat…, in my mind, it doesn't make it any easier, but it makes it easier to swallow (interview 5).

When I asked another rancher what had caused his change in attitude toward beaver, he responded, "I should probably get a little credit for being open minded. I think that was pretty crucial, but seeing all the water available to us—everybody can appreciate that. There's nobody that doesn't get that" (interview 6). One rancher commented that people were accustomed to degraded riparian conditions and lack of beavers in many parts of Elko County prior to the 1990s, when the shift in graz-

ing management occurred. If you are accustomed to landscape conditions being one way, it may not occur to you that they should be any different: "…our normal's generations long, so we can have a hard time getting past that, but people do…. Once I got past that and saw changes, then it got a lot easier" (interview 6). Another rancher interviewed is now completely sold on beaver and their benefits: "I love beavers. I just think they're the neatest thing. My whole attitude with beavers has changed in this 20 years…. I think they're going to be one of the keys to restoration of western streams. Yeah, I think they're going to be very important and they're going to be cheap…" (interview 2).

Legal and Regulatory Framework for Beaver Restoration

In contrast to beaver-related restoration approaches that entail translocation or building artificial structures that mimic beaver dams, an advantage of the Elko County riparian revegetation approach is that no permits are needed; once desirable habitat is built, beavers come on their own. Thus I did not investigate the legal framework for implementing other approaches to beaver-related watershed restoration in Nevada. The two topics I did investigate were beaver management, which influences beaver populations, and water rights.

Beaver Management

Nevada's beaver management policy (Nevada Board of Wildlife Commissioners 2007) aims to protect and conserve beavers while controlling animals that damage land, streams, ditches, and roads or water control structures. It also provides for both consumptive (i.e., trapping) and non-consumptive uses of beaver. Nevada state law requires anyone "taking" a beaver (or other furbearer) using any legal method, or selling fur for profit, to have a trapping license. Beaver season is open statewide from October 1 through April 30, and there is no limit on the number of animals that can be taken (NDOW, n.d.).

When beavers cause damage to property and a landowner complains, the NDOW will issue a depredation permit to the landowner that allows them to control beaver damage to their property. The landowner can do so themselves or hire someone to do so on their behalf, such as a licensed trapper, the U.S. Department of Agriculture's Wildlife Services branch, or NDOW personnel. Ideally, licensed trappers would remove depredating beavers during the regular trapping season. The NDOW also encourages landowners to adopt methods of preventing beavers from damaging their property in the first place (Nevada Board of Wildlife

Commissioners 2007). We were unable to obtain any data regarding the number of beavers removed through depredation permits. Interviewees generally did not view the trapping of beavers as a threat to watershed restoration. Although they have no control over whether people trap beaver on their federal grazing allotments, ranchers interviewed either were not aware of trapping taking place there, or believed it was occurring at such a low level that it was not having a negative impact on beaver populations overall.

Water Rights

Water in Nevada, both surface and groundwater, belongs to the public and is allocated by the Nevada Division of Water Resources (NDWR, n.d.). Nevada water law operates according to the principles of prior appropriation (whoever uses the water in a basin first and claims it has the primary right to its use, and is first to get their water right served, e.g., in a dry year) so long as the rights holder continues to use their water right for a beneficial use (e.g., irrigation, mining, recreation, or municipal applications) (NDWR, n.d.). Nevada Revised Statute 535.060 addresses obstruction of water by beaver dams (Nevada Legislature 2003). If beavers in Nevada interfere with the lawful and necessary distribution of water to its proper users, and are the subject of a complaint in this regard, the state engineer will launch an investigation of the problem. If the investigation is on private lands, and the state engineer finds the complaint to be warranted, the landowner is notified, and arrangements are made for the NDOW to remove the beaver(s). The landowner has a right to object, which may or may not be successful. I found only one instance of beaver removal in response to such a complaint in Elko County in recent years.

Although ranchers interviewed identified a number of benefits from beavers, it is possible that their neighbors do not view them in as positive a light. When I asked interviewees whether neighbors had complained, none reported problems. In part, this may be a result of not having many neighbors. Average ranch size among interviewees was around 300,000 ac (121 405 ha), including federal grazing allotments. Some larger ranches fully encompass whole watersheds, and others had only a few neighboring ranches in the same watershed. Other landowners within shared watersheds often were also participating in the restoration project. As one rancher said, "…nobody's complaining. We've increased the water flows, which has been measured…. There's nothing to complain about, unless they don't want more water" (interview 20).

Conclusions

Not every rancher in Elko County participated in the restoration project described in this case study, nor were all interested in trying new things. As one agency employee said of a permittee they deemed typical of many, "He's still doing the same stuff he did, his grandpa did, and he's still got the same attitude" (interview 14). The majority of ranchers interviewed for this study were open to working with the BLM and Forest Service, and had been doing so, to try new grazing management approaches on their allotments, and to promote watershed recovery and restoration. As one rancher noted, "we're still learning… learning what works and what doesn't and learning about beaver and the whole process has been learning" (interview 6). The process of learning and experimentation in Elko County continues and is expanding. For example, in 2017, the BLM launched its Outcome-Based Grazing Authorizations initiative that includes two ranches in Elko County and nine elsewhere in the West (USDI BLM 2018). The initiative is designed to promote collaborative management of intermixed public and private rangelands by the agency and permittees to achieve mutually identified goals, and provide the flexibility needed to respond to changing ecological conditions (USDI BLM, n.d.). It incorporates many of the principles that developed in Elko County to promote watershed restoration.

From the standpoint of implementing riparian revegetation to encourage beaver colonization and promote watershed restoration, Elko County offers a suite of lessons learned that may inform the success of beaver-related restoration using riparian revegetation in other western rangelands. Important ingredients for success were as follows:

- Low harvest pressure on beavers so populations can grow.
- Large landownerships and grazing allotments—plenty of space for beavers and hay production, a small number of ranchers who influence landscape conditions across a large area, and few neighbors within the same drainage to reduce potentially conflicting management approaches that might compromise restoration goals.
- Grazing practices that are compatible with creating and maintaining beaver habitat—in this case, reducing the frequency and duration of hot-season grazing by livestock in riparian areas through a variety of approaches, depending on the situation and entities involved.
- Agency and permittee flexibility and willingness to try new grazing management approaches.
- Strong collaborative relations among agency staff and permittees fostered by long-term relationship and trust building.

- Site visits by local ranchers to ranches that demonstrate new management-approach benefits for both livestock and the environment.
- Research and monitoring to document project outcomes and help build support for projects that demonstrate successful restoration.

Ultimately, what the champions of change in Elko County are working toward is the vision articulated by one rancher:

> I think we're one of those places that we're saying, "Hey, we can have a bunch of cows and a bunch of elk and a bunch of beaver and a bunch of sage grouse and a bunch of water, and it can all be there. We can be profitable and you can be proud, and the land can flourish. Our economies, our communities… all of it can happen. We don't have to hate each other" (interview 3).

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Appendix: Outcomes of Beaver Colonization in Elko County, Nevada, Watersheds

Hydrogeomorphic Outcomes

Areal extent of surface water—

***Susie Creek basin*—**Kilometers of visible, wetted stream in 1991 and 2013 increased in two Bureau of Land Management (BLM) grazing allotments (+0.1 and +2.6 mi [+0.2 and +4.2 km] of stream, respectively), and decreased in one allotment (-2.4 mi [-3.9 km]). The increase was attributed to an increase in open water (this may be attributed to beaver impoundments, although the report doesn't specify); the decrease was attributed to differences in water-year precipitation (Fesenmyer et al. 2015).

Susie Creek basin—There was an increase in land-cover type classified as "water" in all comparable reaches of the Susie Creek mainstem between 1991 and 2013 (+260.6 percent within one grazing allotment, +100 percent in another, and +94.1 percent in a third). These increases were attributed in part to an increase in the number of beaver impoundments over time (Fesenmyer et al. 2015).

Maggie Creek basin—The extent of open water on Maggie Creek (beaver ponds, stock ponds, mine ponds, reservoirs) within the restoration area increased between 2006 and 2010, mostly along the Maggie Creek mainstem. Beaver ponding increased from 6.9 to 15.9 linear mi (11.1 to 25.6 km) during this period in the study area as a result of beaver impoundments creating pools behind dams, mostly along Maggie Creek. Beaver are primarily responsible for the trend toward more hydric conditions (White Horse Associates 2011).

Groundwater—

Maggie Creek basin—Riparian corridors with a >25 percent transition ratio increased from 36.3 mi (58.4 km) in 2006 to 64.3 mi (103.4 km) in 2010 inside the restoration project area, indicating a trend toward rising groundwater levels. Continuous streamflow increased from 24 mi (38.6 km) in 2006 to 29 mi (46.6 km) in 2010. Both are considered to be a result of higher groundwater levels caused by beaver dams, which have increased in number since 2006 (White Horse Associates 2011).

Stream condition—

Maggie Creek basin—Stream condition in the restoration project area improved between 2006 and 2010, with a rejuvenation of secondary channels in the Maggie Creek watershed. Stream/riparian corridors in proper functioning condition increased from 34 mi (54.7 km) in 2006 to 41 mi (65.9 km) in 2010. These

improvements are attributed to higher groundwater levels caused by beaver dams (White Horse Associates 2011).

Ecological Outcomes

Riparian vegetation and resources—

Susie Creek basin—Riparian vegetation increased in the three BLM grazing allotments assessed between 1991 and 2013 (+171.4 percent in one, +218.3 percent in another, and +66.1 percent in a third). Some or much of this change may be related to the growth of beaver populations and their dams (Fesenmyer et al. 2015).

Salmon Falls Creek basin—Between 1986 or 1995 (depending on availability of aerial photos) and 2010, there was a positive change in the amount and percentage of riparian vegetation along most major streams in the basin on sampled Forest Service and BLM allotments. Riparian vegetation increased on 55 percent of major streams across allotments by at least 25 percent. A strong positive trend in productivity of riparian vegetation along many major streams that run through the allotments also occurred between 1985 and 2014, and were unrelated to precipitation. The greatest increases occurred in larger, perennial streams that showed evidence of increased beaver activity during that period. Positive changes in the amount of riparian vegetation and riparian zone productivity seem to be associated with the number of beaver dams in pastures, which increased by 165 between 1995 and 2013. This increase is correlated with the introduction of "conservation grazing" (Fesenmyer 2016).

Squaw Valley BLM allotment—Between 1976 and 2013, the amount of riparian vegetation growing within the potential riparian area on the allotment expanded in nearly all of the stream reaches measured. The most dramatic changes occurred after 2004, when livestock grazing management improved, leading to more than a fivefold increase of riparian vegetation within the potential riparian area. The number of beaver dams on the allotment also increased from 8 in 1998 to 30 in 2013 (Open Range Consulting 2015).

Maggie Creek basin—The total area of riparian/water resources in stream corridors within the restoration project area increased from about 520 ac (210.4 ha) in 2006 to 706 ac (285.7 ha) in 2010. The total area of riparian/water resources in riparian corridors increased from 2,126 ac (860.3 ha) in 2006 to 2,592 ac (1048.9 ha) in 2010. The increase in riparian/water resources is considered to be a result of beaver impoundments (White Horse Associates 2011).

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